

Appendix L

Analysis of Candidate Resource Portfolios

Structure of the Candidate Resource Portfolios

The candidate resource portfolios are constructed, based upon various strategies, of qualifying renewable, non-renewable, renewable energy credits (RECs) and conservation resources under the two main constraints of resource adequacy (95 percent reliability measure) and Initiative 937, so that different combinations of these resources satisfy both constraints.¹

The candidate resource portfolios contain all of the resources in the base portfolio (City Light's current portfolio); in addition, because of the need for resources (winter resource adequacy and I-937), different mixes of qualifying resources are added to each of the candidate portfolios in the form of power contracts, depending on each portfolio's strategy. The performance of each of these portfolios under expected demand and supply is evaluated based upon the financial costs of the portfolios, their embedded environmental costs, and their degree of risk. A detailed listing of each of the candidate resource portfolios is found at end of this appendix. A summary of the candidate resource portfolios is in Figure 1.

Resource Mix

The following resources are variously combined to construct the candidate resource portfolios, and the names of the candidate resource portfolios are chosen to somewhat describe the dominant resource among all the resources in each resource portfolio.

- Seasonal Exchanges
- Biomass (Cogeneration and Combustion Stoker)
- Geothermal
- Wind
- Landfill
- Single Cycle Turbine (SCT)
- Combined Cycle Turbine (CCT)
- Small Hydro
- Conservation
- Combined Heat and Power (CHP)

Figure 1. Candidate Resource Portfolios

Candidate Portfolio	2020 New Renewables (aMW)	2020 RECs (MWh)	Resource Strategy
1 RECs-Only	5	981,120	Rely on the market for power and RECs
2 Lo-RECs	119	35,040	Meets targets with mostly resources
3 Med-RECs	30	420,480	Blend of RECs and resources
4 Hi-RECs	75	814,680	RECs for I-937, resources for reliability
5 Gas & Max RECs	5	981,120	Natural gas (CCT) and maximum RECs
6 Wind & Gas	105	157,680	Lots of wind, natural gas (SCT)
7 Hi-Cons.	112	78,840	Higher conservation (5-year plan targets)
8 Max Exchanges	88	306,600	Highest level of exchanges
9 Cons.: Load Growth	29	823,440	Less conservation, at pace of load growth

Renewable Energy Credits (RECs)

Evaluation of alternative REC strategies is an important issue in the 2010 IRP. City Light has sufficient firm generation resources, making RECs a plausible approach to compliance with I-937, Washington's renewable portfolio standard. Targets for compliance with I-937 were established based upon the formula stated within the 2006 Act and City Light's system load forecast. Various mixes of renewable resources and RECs were included within the design of the nine candidate resource portfolios, each of which complies with the dual requirements of I-937 and energy for winter reliability. The future REC requirements for each candidate resource portfolio were calculated as the shortfall in megawatt-hours (MWhs) of qualifying renewable generation from expected I-937 requirements in each year. REC prices were forecast as the difference in cost between non-renewable generation and renewable generation. A natural gas combined cycle turbine was selected to represent non-renewable generation, while wind generation was selected to represent renewable generation. The difference in their costs represents the difference in environmental attributes, or RECs. In the base case, the levelized cost of the RECs was \$38 per MWh for the 20-year forecast period. The total REC costs and new resource costs for each portfolio were considered when evaluating candidate resource portfolios.

Performance Measures

City Light has selected two measures to analyze and rank the performance of the candidate resource portfolios for the first round of portfolio analysis: 1) the net present value (NPV) of the net power costs (NPC)² of the candidate resource portfolios over the 20-year study period, and 2) a descriptive statistical measure called the coefficient of variation³ of the net power costs (NPC) of each resource portfolio in order to capture the degree of risk of the resource portfolios. The resource costs include environmental costs such as air emissions (CO₂, SO_x, and NO_x), mercury and particulates.

Portfolio Performance and Final Results

City Light first completed deterministic⁴ studies, assuming the expected supply and demand, for the study period of 2010-2029. Then, the net present value and the coefficient of variation of the yearly net power costs for each resource portfolio were calculated to determine each portfolio's performance under expected conditions and environmental constraints. Figure 2 illustrates the net present value of each resource portfolio after taking into account the REC requirements for each.

Figure 2. 20-Year Net Present Value of Costs for Candidate Portfolios

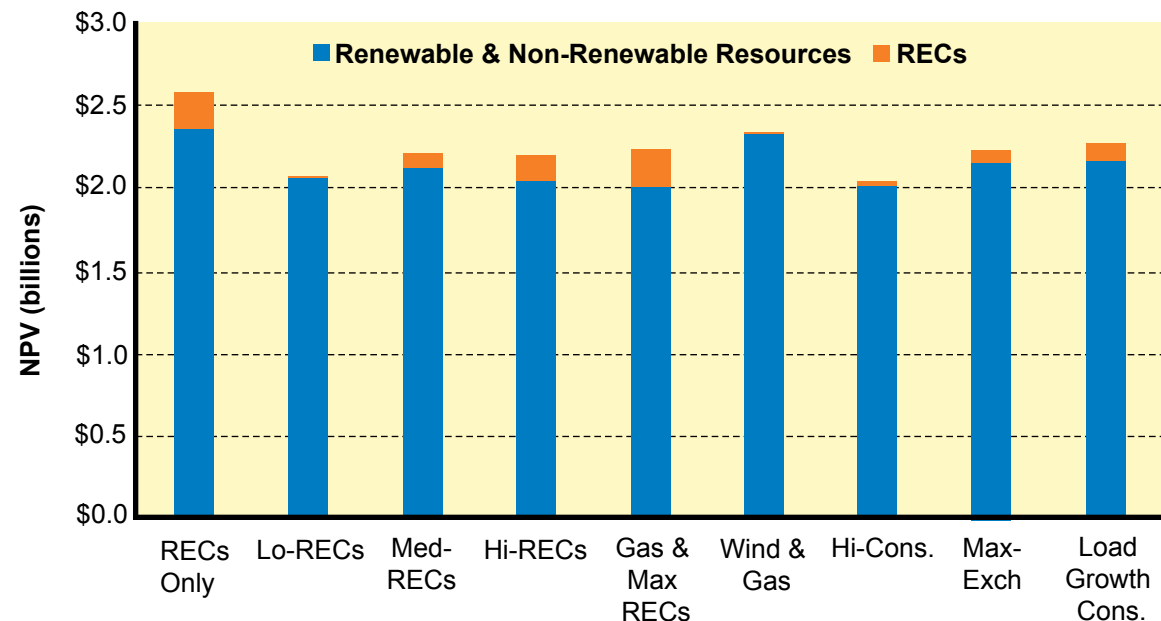


Figure 3 illustrates the degree of risk (CV, the coefficient of variation) of each resource portfolio.

After taking into consideration the NPV of each resource portfolio and associated CV, City Light selected the following resource portfolios as the best performing resource portfolios for the first round of analysis.

- Higher Conservation
- High RECs
- Medium RECs
- Low RECs
- Maximum Exchange

Second Round of Portfolio Analysis

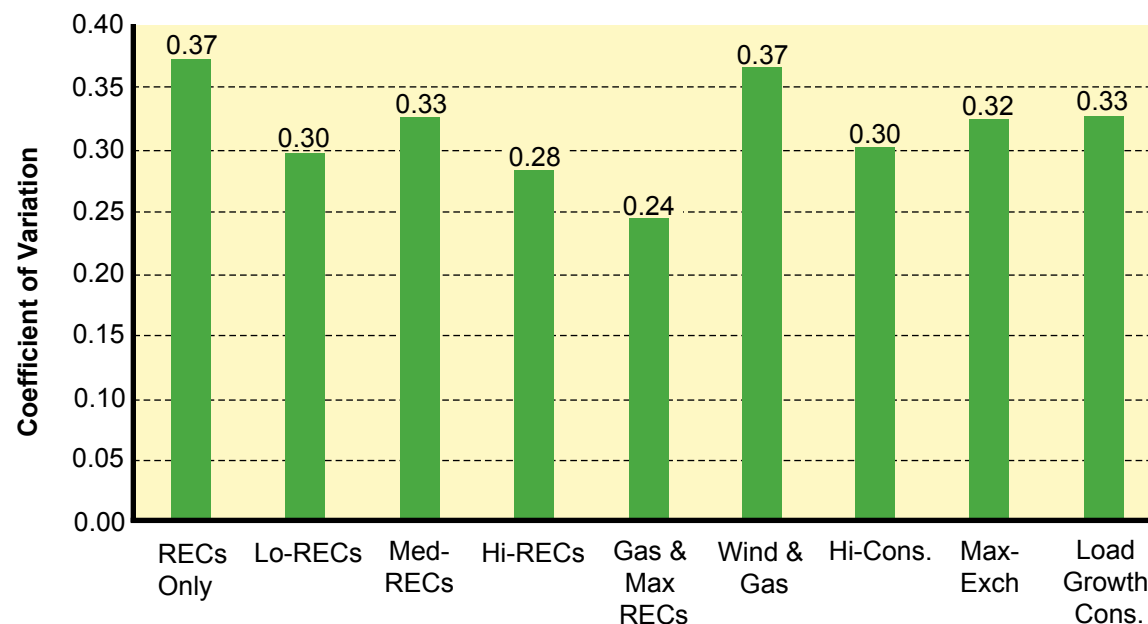
As part of the 2010 IRP process, the Seattle City Council has directed City Light to provide the top performing candidate resource portfolios for their consideration. A stochastic risk analysis was performed to provide more exact information about the degree of risk in the remaining five candidate resource portfolios. Armed with both the cost information (developed in the first round) and the stochastic risk analysis, the relative performance of the remaining five candidate portfolios was more evident. Two of the remaining five candidate portfolios were dropped from further consideration. The remaining three candidate resource portfolios

were then presented to the Seattle City Council's Energy, Technology, and Civil Rights Committee for their consideration. Following the presentation to the Committee, the remaining three resource candidate resource portfolios were further tested with eight scenarios of the future. These scenarios were:

- High Demand
- Low Demand
- High Natural Gas Prices
- Low Natural Gas Prices
- High Cost of Carbon Emissions
- Low Cost of Carbon Emissions
- High RECs Costs
- Low RECs Costs

The analysis of the eight scenarios is described in the 2010 IRP document beginning on page 25. The preferred portfolio performed the best in five of the eight scenarios, in expected cost, and in the two risk measures.

Figure 3. Coefficient of Variation for Portfolio 20-Year Net Power Cost



Candidate Portfolio Detail

LO-RECs (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	10	23	37	51	65	79	93	107	112	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Option											24	24	24	24	24	24	24	24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CHP/DG																				
Geothermal 1											18	18	18	18	18	18	18	18	18	18
Biomass 1: Cogen							14	14	14	14	14	14	14	14	14	14	14	14	14	14
Biomass 2: Cogen							14	14	14	14	14	14	14	14	14	14	14	14	14	14
Wind 1											38	38	38	38	38	38	38	38	38	38
Wind 2											24	24	48	48	48	48	48	48	48	48
Wind 3												30	30	30	30	30	30	30	30	30
RECs							5	7	9	10	4	11		2	4	6	7	9	11	7

HI-RECs (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	10	23	37	51	65	79	93	107	112	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Option									24	24	24	24	24	24	24	24	24	24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2										5	5	5	5	5	5	5	5	5	5	5
CHP/DG										6	6	6	6	6	6	6	6	6	6	6
Geothermal 1													18	18	18	18	18	18	18	18
Biomass 1: Cogen															14	14	14	14	14	14
Biomass 2: Cogen											14	14	14	14	14	14	14	14	14	14
Wind 1												32	32	32	32	32	32	32	32	42
Wind 2																24	24	24	24	24
RECs							37	39	41	31	93	97	93	95	83	61	62	16	18	10

MED-RECs (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	10	23	37	51	65	79	93	107	112	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Option								24	24	24								24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CHP/DG													6	6	6	6	6	6	6	6
Geothermal 1											18	18	18	18	18	18	18	18	18	18
Biomass 1: Cogen												14	14	14	14	14	14	14	14	14
Biomass 2: Cogen											14	14	14	14	14	14	14	14	14	14
Wind 1												32	32	32	32	32	32	32	32	32
Wind 2																24	24	24	24	24
Wind 3											32	32	32	32	32	32	32	32	32	32
RECs							32	34	36	37	48	39	47	49	51	29	30	32	34	36

GAS & MAX-RECs (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	10	23	37	51	65	79	93	107	112	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Option									24	24	24	24	24	24	24	24	24	24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CCT											121	121	121	121	121	121	121	121	121	121
RECs							32	34	36	37	112	149	163	165	166	168	170	171	173	169

WIND & GAS (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	10	23	37	51	65	79	93	107	112	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Option																		24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Wind 1											64	64	64	64	64	64	64	64	64	64
Wind 2							24	24	24	24	24	24	24	24	24	24	24	24	24	24
Wind 3												64	64	64	64	64	64	64	64	64
SCT														41	41	41	41	41	41	41
RECs									12	13	18		5	7	8	10	12	13	15	17

HIGHER CONS. (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	14	30	46	61	74	87	100	113	124	127	130	131	132	133	134	135	136	138	139	140
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			20	20	20	20	20	20	20	20	20	50	50	50	50	50	50	50	50	50
Priest Rapids Option								24	24	24	24	24	24	24	24	24	24	24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CHP/DG														6	6	6	6	6	6	6
Geothermal 1										18	18	18	18	18	18	18	18	18	18	18
Biomass 1: Cogen							14	14	14	14	14	14	14	14	14	14	14	14	14	14
Biomass 2: Cogen											14	14	14	14	14	14	14	14	14	14
Wind 1											32	32	32	32	32	32	32	32	32	32
Wind 2											24	24	24	24	24	24	24	24	24	48
Wind 3												48	48	48	48	48	48	48	48	48
RECs							17	19	22	4	9		11	7	9	11	13	15	17	

MAX-EXCH. (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	10	23	37	51	65	79	93	107	112	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 3								50	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Conversion																		24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
CHP/DG																				
Geothermal 1											18	18	18	18	18	18	18	18	18	18
Biomass 1: Cogen							14	14	14	14	14	14	14	14	14	14	14	14	14	14
Biomass 2: Cogen											14	14	14	14	14	14	14	14	14	14
Wind 1											32	32	32	32	32	32	32	32	32	32
Wind 2												48	48	48	48	48	48	48	48	48
Wind 3																16	16	16	16	16
RECs							18	20	23	24	35	23	37	39	41	27	28	30	32	34

CONS-L.G. (aMW)

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Conservation	12	24	36	48	60	72	84	96	108	114	116	118	120	122	124	126	128	130	132	134
Exchange 1		50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50
Exchange 2			35	35	35	35	35	35	50	50	50	50	50	50	50	50	50	50	50	50
Priest Rapids Option							24	24	24	24	24	24	24	24	24	24	24	24	24	24
Landfill Gas	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Gorge Tunnel 2						5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Geothermal 1											18	18	18	18	18	18	18	18	18	18
Biomass 1: Cogen														14	14	14	14	14	14	14
Biomass 2: Cogen															14	14	14	14	14	14
Wind 1												42	42	42	42	42	42	42	42	42
Wind 2																		48	48	48
Wind 3																16	16	16	16	32
RECs							32	34	37	38	94	89	103	91	79	65	67	20	22	8

¹ Non-renewable resources such as combustion turbines and coal plants do not satisfy I-937 requirements. RECs do not satisfy the resource adequacy need requirements.

² Net power cost (NPC) is the sum of the costs of owned power generating resources, power contracts and net exports (the difference between market sales and market purchases).

³ A statistical measure of the dispersion of data points in a data series around the mean. This measure is calculated as follows:

$$CV = \frac{\sigma}{\mu}$$

This statistical measure is very useful for comparing the degree of variation from one data series to another, even if the means are significantly different from each other.

⁴ A deterministic system is one in which no randomness is involved in the development of future states of the system. A deterministic model always produces the same output from the given starting (initial) condition for a set of variable states.

⁵ A stochastic process is a random process that is the counterpart to a deterministic process. A stochastic process has some indeterminacy in its future evolution described by probability distributions. This means that even if the initial conditions of a set of variable states are known, there are still many possibilities (paths) the process might follow, creating a degree of uncertainty about the outcomes.